Variation of Short-Scale Waves in the Shoaling Zone

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LONG -TERM GOAL

Goals are to provide measurements of short-scale sea surface roughness in the shoaling wave zone, determine the correlation between this short-scale slope variance and surface wind stress, and finally suggest the ramifications to microwave remote sensing in the shoaling zone.

SCIENTIFIC OBJECTIVES

Primary objective is to determine the characteristics of near-vertical incidence millimeter-wave radar backscatter in the surf zone and out to sea. This information relates directly to an integration of the sea surface spectrum over wave scales from 1 m down to 1 cm. The short-scale waves are known to be well-coupled to the wind stress. Technical objective will be to obtain collocated wind stress, long wave, and absolutely calibrated near-vertical radar scattering data together over the shoaling zone.

APPROACH

We have fabricated and flown a simple down-looking scatterometer (DLS) on the NOAA LongEZ as a team member in J. Sun's project entitled 'Spatial Variation of the wave, stress, and wind fields in the shoaling zone'. Aircraft size dictates that the radar frequency be quite high (smaller antenna aperture). A 36 GHZ (Ka-band) transmit frequency has been chosen. The radar is a simple CW scatterometer making an absolute power measurement. Radar data are being related to the small-scale surface slope using ocean scattering models already developed. These data are a well suited complement to the longer-wave slope data being derived from the LongEZ laser sensors. Together we are able to accurately measure the variability of wave slope in the coastal zone which is an important component in models for moderate to grazing incidence angle radar scattering.

WORK COMPLETED

As of Oct. 1998, the radar has been designed, built, installed on the LongEZ and successfully flight tested during an extended pilot experiment near Duck NC in Nov. 1997. We call the system a down-looking scatterometer (DLS) and some details related to the DLS can be seen at http://rows.wff.nasa.gov/dls.html. Necessary post flight modifications have been made in anticipation of the multiple ONR-funded experiments planned in 1999.

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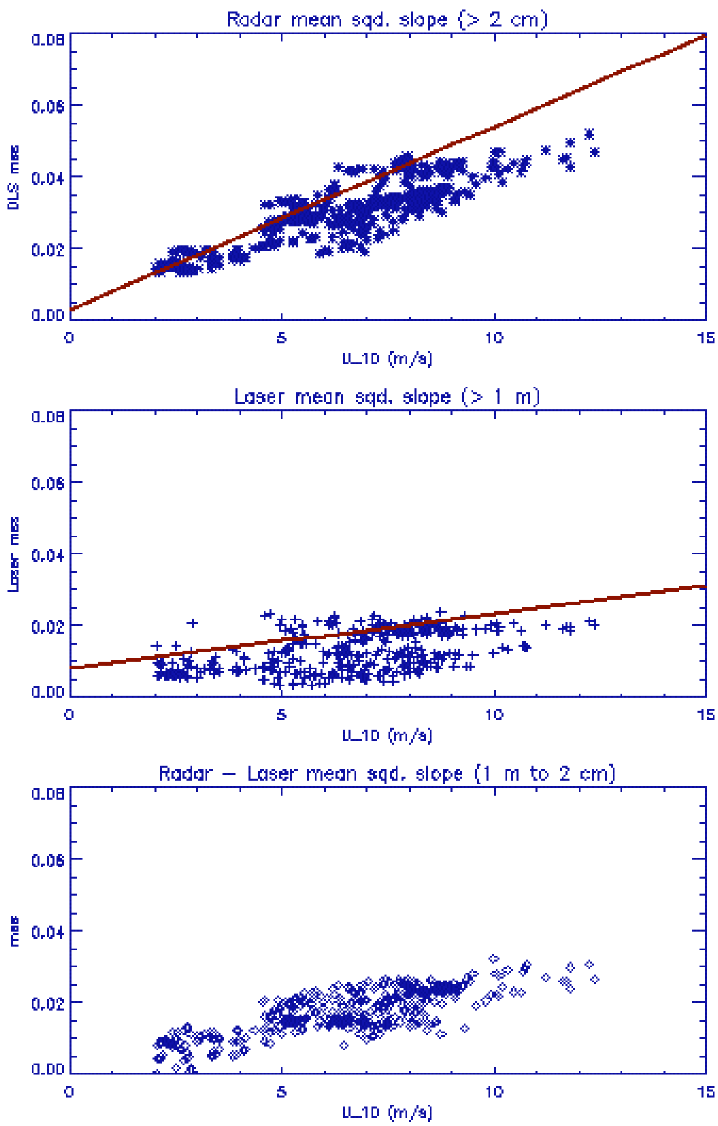
The pilot experiment of 1997 was quite successful. Data from 8 flights during the pilot experiment have been processed and a data set assembled that includes parameters derived from the radar as well as the LongEZ lasers and gust probe.

RESULTS

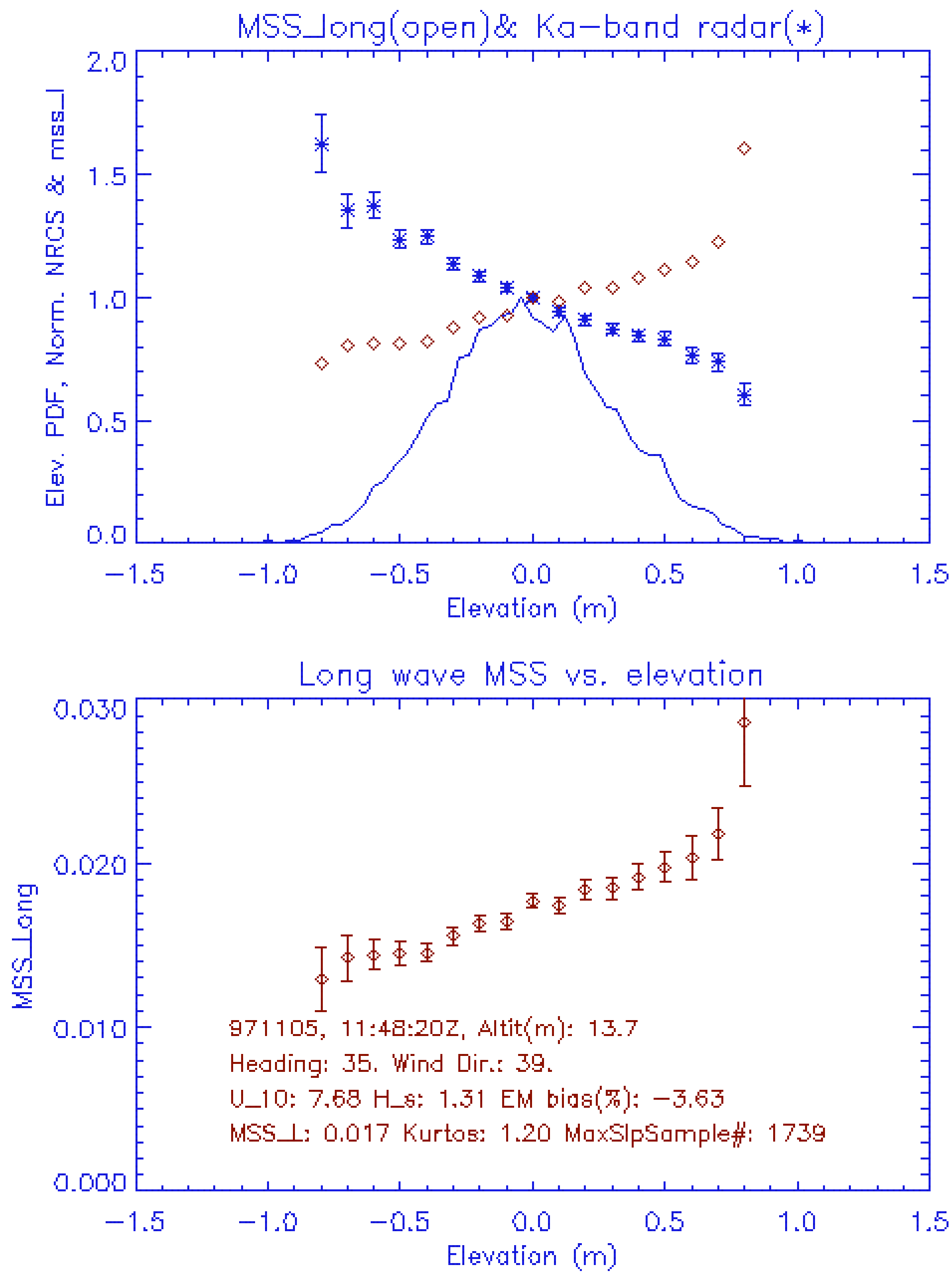
The pilot experiment of Nov. 1997 provided ample data to evaluate the radar and laser data over a variety of wind and wave conditions. See the 'related projects' section below for further reports on the overall experiment. This initial data set clearly shows the promise for using the laser and radar data to characterize the surface slope, both in a bulk, or averaged, sense as well as for high spatial resolution study where wave structure within the long wave field can be examined.

At this early stage two examples of the derived surface slope variances are provided. The first figure shows LongEZ-derived wind speed vs. 'bulk' slope variance generated for 3km ocean flight segments from the DLS (radar), laser, and a hybrid short-wave parameter formed by differencing the laser and radar results. The lines on the upper two plots are the predicted slope variances for clean(total) and slick(long waves only) surfaces of Cox and Munk(1954). The general correlation between our slope observations and wind speed indicates that our slope variances are closely



associated with the surface stress. Future study is addressing the variation of these parameters versus u*, fetch, shoaling , sea state and wave breaking.

The second figure illustrates the variability of the surface slope variance with surface elevation as measured during the pilot experiment. The top figure displays the elevation PDF and the variation of normalized radar backscatter (inverse of total slope variance) and laser-derived long wave slope as a function of surface elevation. These data illustrate the well-known ‘electromagnetic bias’ where the surface troughs are smoother than the crests. What is not well-known are what wave scales are primarily responsible for the phenomena. The combination of radar and laser slopes will be used to address this. What we found in the pilot experiment was that 1) variations with elevation are quite dependent on surface conditions including proximity to the coast, 2) the long wave (laser) and total(radar) EM bias estimates are not always well correlated.



IMPACT

We expect the impact of these results to come in an improved understanding of how to better use microwave remote sensing in the shoaling zone.

TRANSITIONS

N/A

RELATED PROJECTS

As mentioned above, this work is directly related to the NOAA LongEZ shoaling zone activities headed by J. Sun. (cf. Sun:N00014-0-98-1-0245, Mahrt:N00014-0-98-1-0282, and Crawford:N00014-97-F-0123)This work is also closely related to NASA's Earth Science Enterprise research efforts to improve estimation of ocean sea level and wind speed as extracted from satellite altimeters, scatterometers and radiometers. A NASA-funded LongEZ field experiment addressing altimeter electromagnetic bias determination is planned for Nov. 1998 near Duck, NC. This work is in support of the Jason-1 altimeter program of CNES/NASA.